



Deep Learning Project Presentation

Automated Quality Inspection:

Develop an automated quality inspection system for a manufacturing shopfloor that uses machine vision and AI to detect defects in real-time, and increase production quality.

Key Areas: Machine vision, artificial intelligence, quality control.

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24/DSC/09

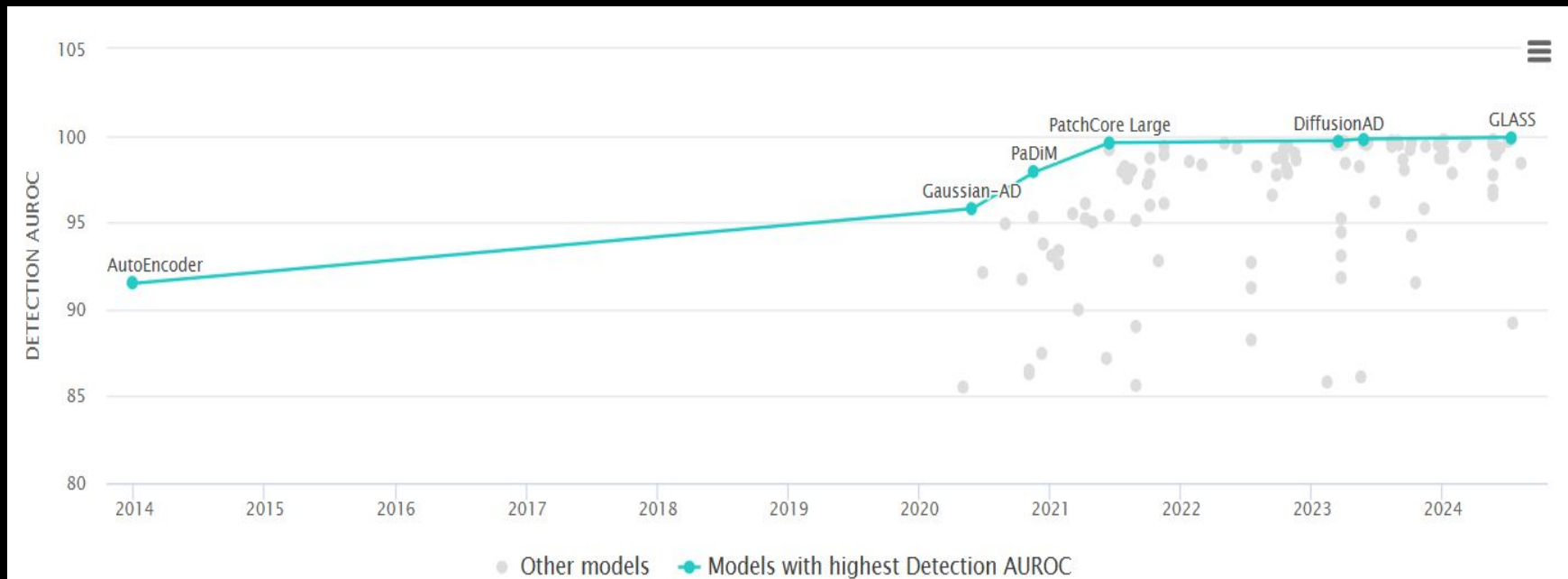
PROBLEM STATEMENT

- This project focuses on implementing and showcasing two anomaly detection techniques using deep learning with a ResNet backbone:
 - **The Autoencoder**, a classic self-supervised approach that leverages reconstruction errors for anomaly detection. and
 - **The PatchCore**, a state-of-the-art unsupervised method that utilizes patch-level feature embeddings for precise anomaly identification.
- The objective is to understand the underlying concepts and demonstrate the effectiveness of both techniques in identifying anomalies on a benchmark dataset.

Why the selected problem is relevant?

- **Industrial Importance:** Anomaly detection is critical in various industrial applications such as manufacturing, where identifying defects or abnormal behavior ensures product quality and operational safety.
- **Early Fault Detection:** Early identification of equipment malfunctions or production issues, reducing downtime and preventing costly breakdowns
- **Scalability and Adaptability:** By examining both methods, this project highlights the trade-offs between interpretability, computational complexity, and detection accuracy, addressing the practical concerns of deploying anomaly detection systems at scale

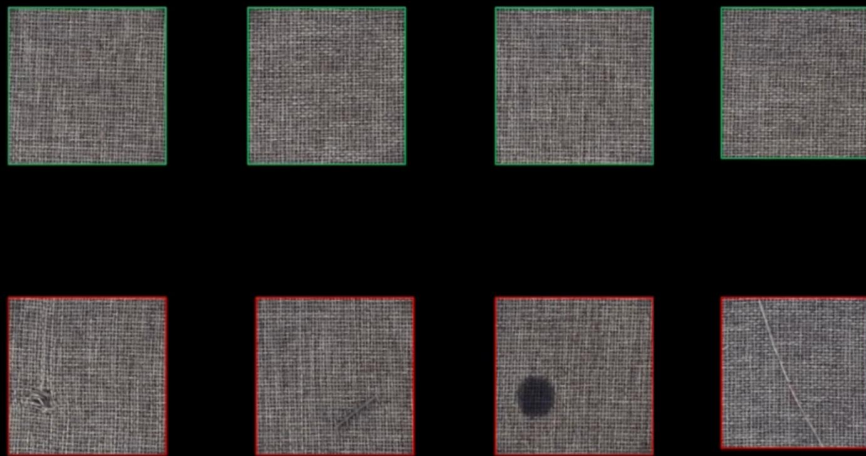
Most notable existing works in this problem space



Significant works on anomaly detection in past few years

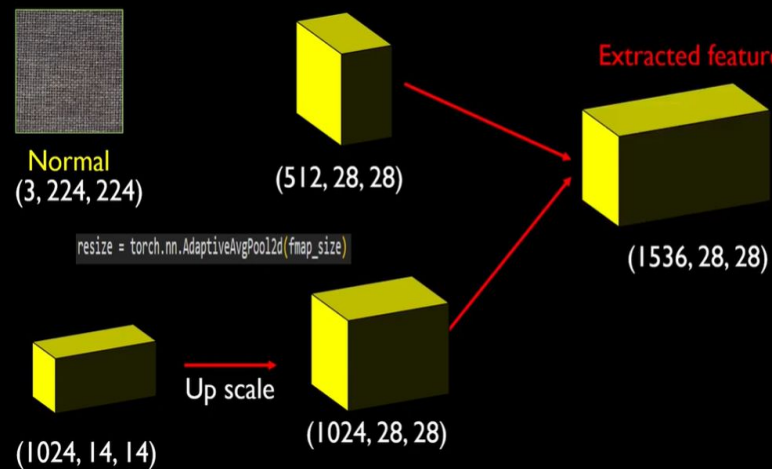
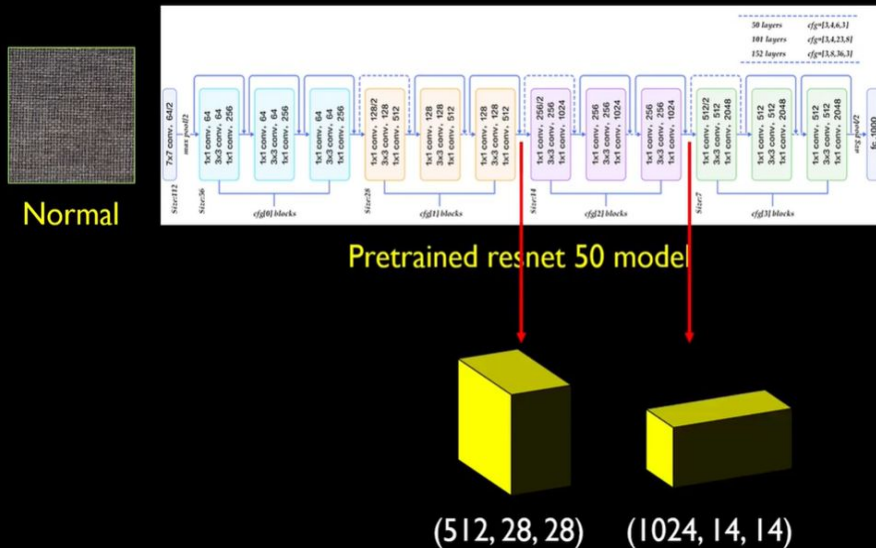
MVTec AD Dataset

MVTec AD dataset contains 5354 high-resolution color images of different object and texture categories. It contains normal, i.e., defect-free, images intended for training and images with anomalies intended for testing. The anomalies manifest themselves in the form of over 70 different types of defects such as scratches, dents, contaminations, and various structural changes.



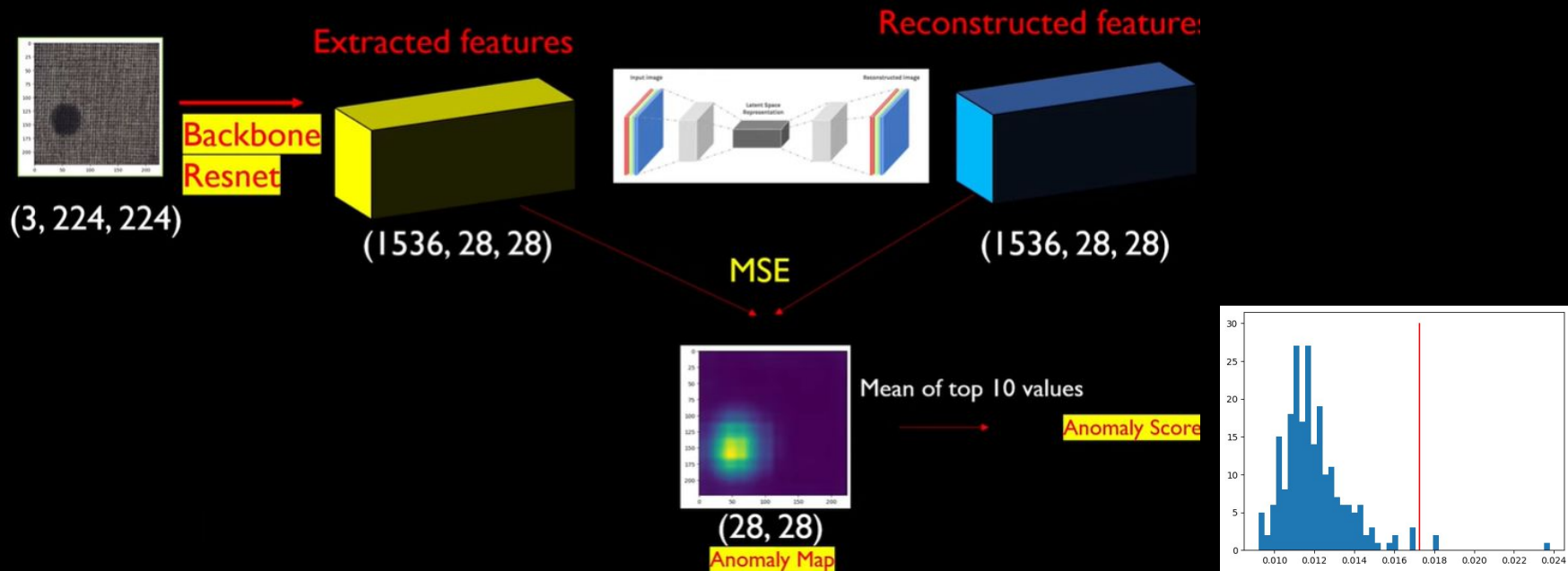
METHODOLOGY: ResNet as Backbone

ResNet serves as the backbone for both the Autoencoder and PatchCore models due to its powerful feature extraction capabilities, enabling them to leverage deep hierarchical representations for effective anomaly detection



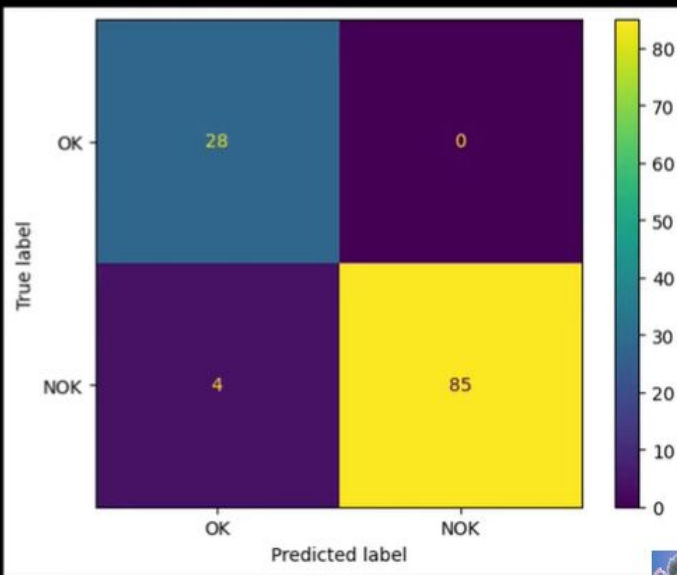
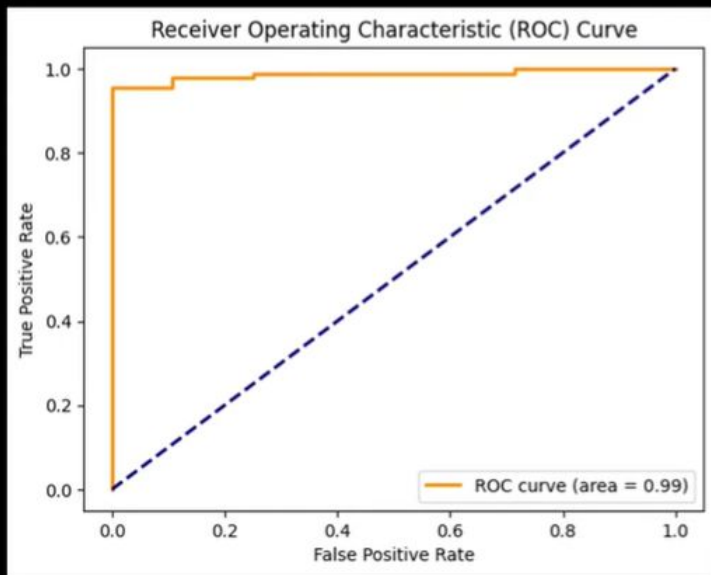
METHODOLOGY: Autoencoder

Extracted features from Resnet are fed to Autoencoder and reconstruction error is calculated from which **Anomaly Map** and **Anomaly Score** are extracted.

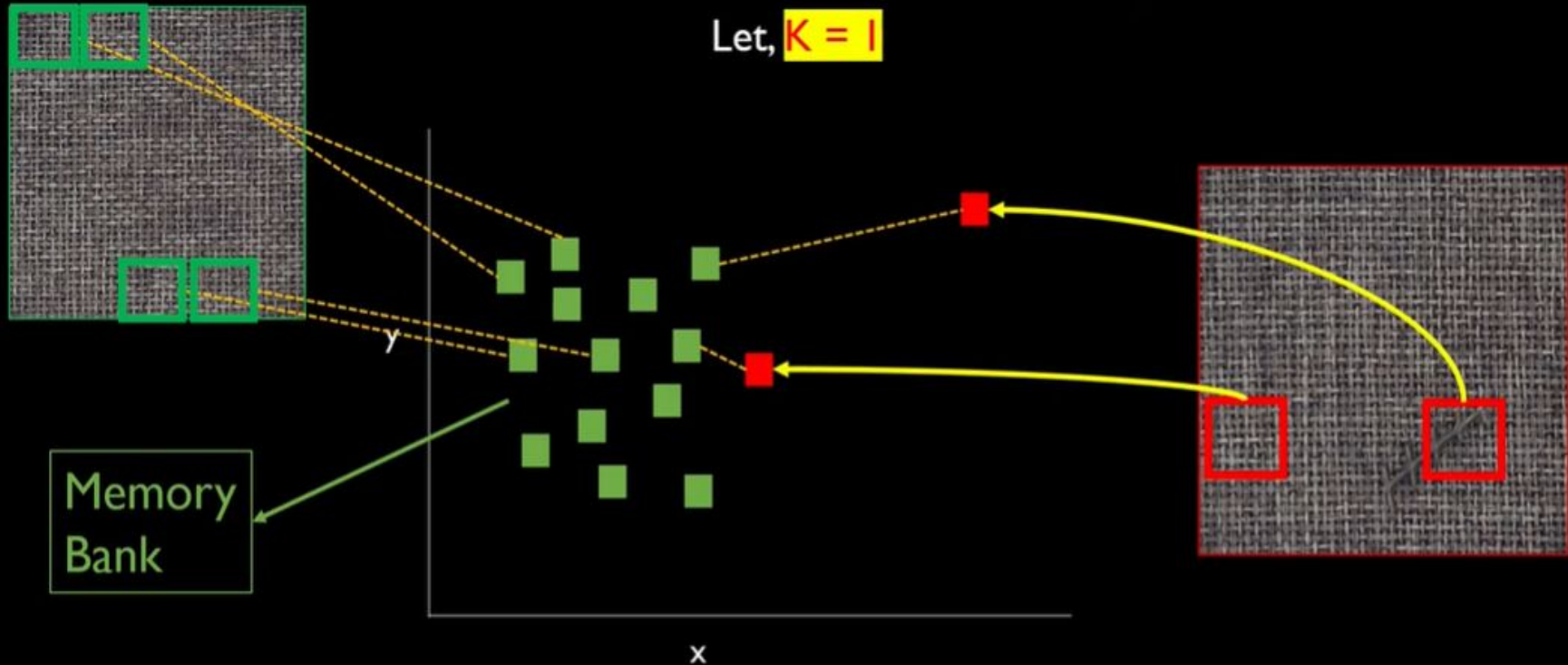


EXPERIMENTAL RESULTS: Autoencoder

- It gave satisfying results if we perform on single category (carpet)
- Training time is reasonable
- Anomaly detection performance can be improved if we leverage the each patch information instead of the whole image information.



PATCHCORE: KNN for Distance Scores



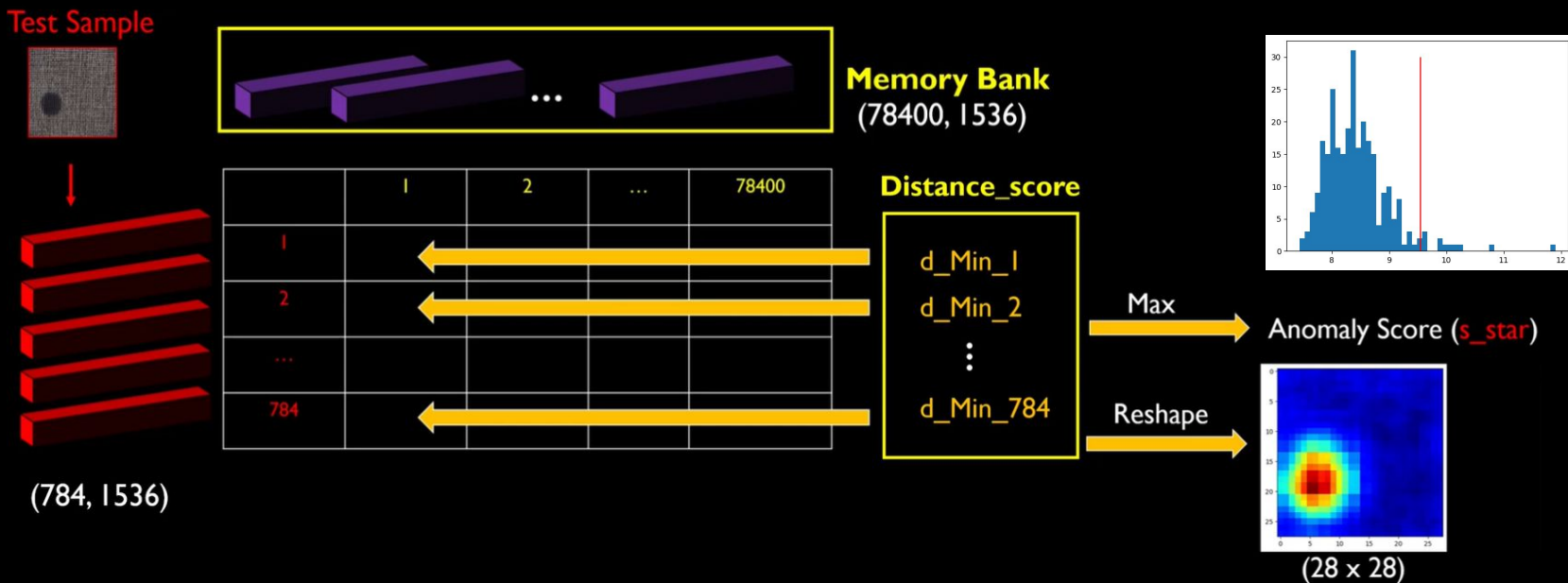
PATCHCORE: Patch features and Memory bank

Extracted features from Resnet are divided into patches. These patches of all the training data form the memory bank of patch core



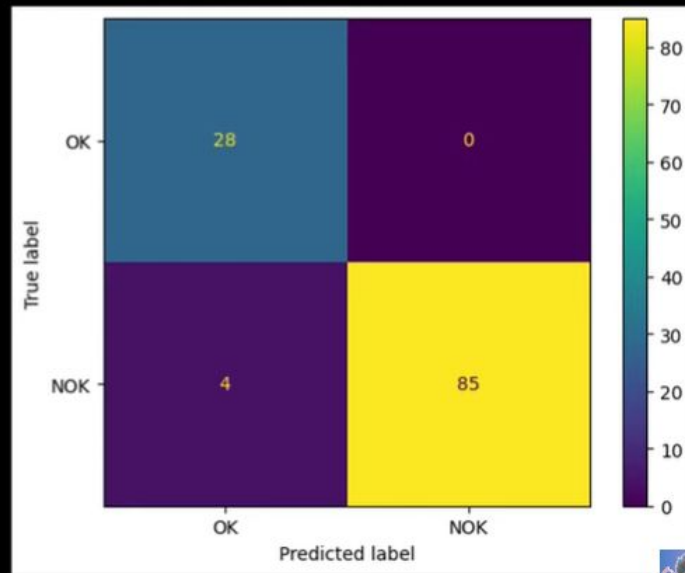
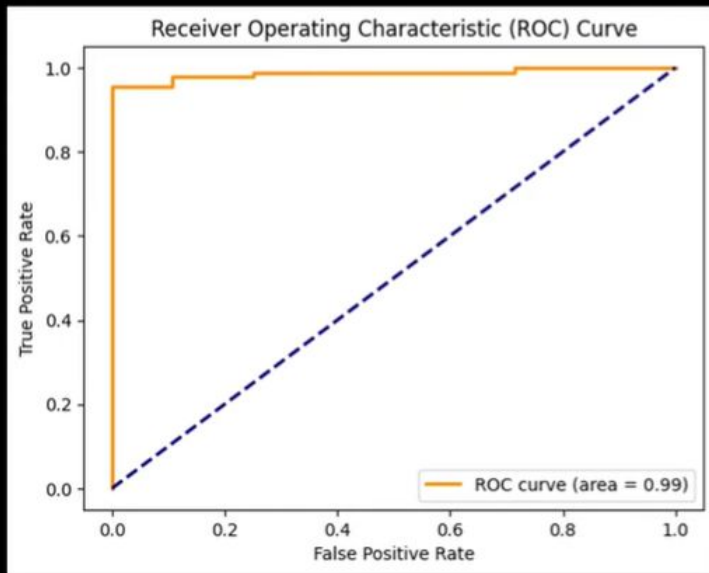
PATCHCORE: Anomaly score calculation

- Extracted features from Resnet are divided into patches. These patches of all the training data form the memory bank of Patchcore.
- Distance scores of test sample are calculated by taking row minimum of distance between its patch and the memory bank. And Anomaly score is max of distance scores.

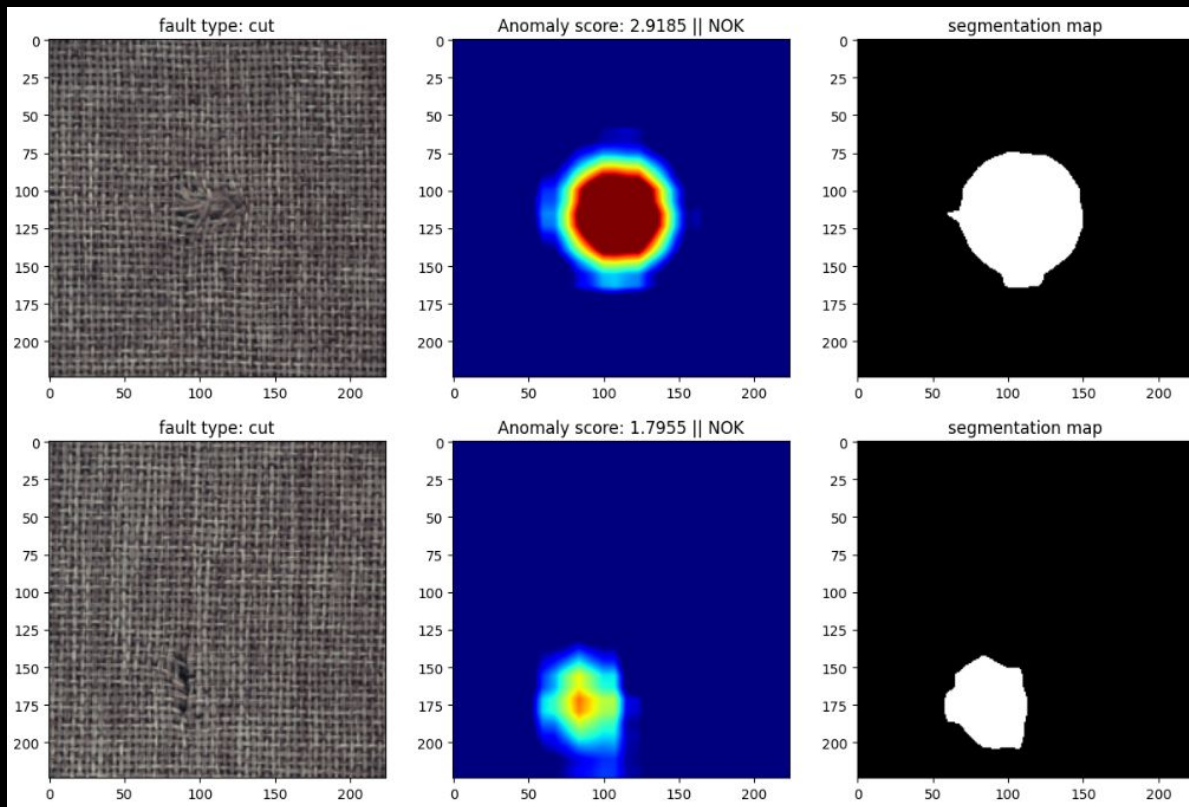


EXPERIMENTAL RESULTS: PatchCore

- It gave satisfying results for all categories
- No training time needed
- More precise anomaly detection is seen



EXPERIMENTAL RESULTS: PatchCore



FUTURE WORK

- In patchcore approach, we randomly sampled 10% of the memory bank to enhance computation
- This can be done in more systematic way like coreset sampling or learned sampling
- New techniques like Diffusion-AD, GLASS came up for anomaly detection which can be explored.

MY LEARNINGS

- Understanding of Autoencoder and Patchcore concepts.
- Improved practical skills in implementing deep learning models from scratch
- Enhanced skills in data preprocessing and visualization
- Deepened understanding of various performance metrics for evaluation of model
- Facing challenges in Anomaly Detection like best threshold estimation
- Identified the limitations of each methods
- Insight into the real-world significance of anomaly detection

REFERENCES

- K. Roth, L. Pemula, J. Zepeda, B. Schölkopf, T. Brox, and P. Gehler, “Towards total recall in industrial anomaly detection,” in Proceedings of the International Conference on Machine Learning (ICML), 2020.
- J. Yang, Y. Shi, and Z. Qi, “DFR: Deep feature reconstruction for unsupervised anomaly segmentation,” in Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), June 2021.
- Pytorch documentation

THANK YOU